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JOHNS HOPKINS ALL CHILDREN'S HOSPITAL

Post-Cardiac Arrest Care Pathway

Post-Cardiac Arrest Care Pathway

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This pathway is intended as a guide for physicians, physician assistants, nurse practitioners and other healthcare providers. It should be adapted to the care of specific patient based on the patient's individualized circumstances and the practitioner's professional judgment.

Johns Hopkins All Children's Hospital

Post-Cardiac Arrest Care Pathway

Rationale

This clinical pathway was developed by a consensus group of JHACH physicians, advanced practice providers, nurses and pharmacists to standardize the management of children and young adults hospitalized with cardiac arrest. Comprehensive post-cardiac arrest care is necessary to address the systemic effects of the ischemia-reperfusion injury following cardiac arrest. Evidence suggests this is critical for both patient survival and optimal neurological outcome.

It addresses the following clinical questions or problems:

1. When to evaluate for etiology and sequelae of cardiac arrest.
2. What evaluation to perform based on post-arrest mental status.
3. What clinical goals to aim for optimizing potential outcome.
4. What consults to consider in the post-arrest patient.

Background

It is estimated that > 5000 children experience out of hospital cardiac arrest (OHCA) and an estimated 6000 children develop in hospital cardiac arrest (IHCA) annually in the United States. Children who obtain return of sustained circulation (ROSC) will develop post cardiac arrest syndrome (PCAS). PCAS is a pathophysiologic response to cardiac arrest that has 4 key components: post-cardiac arrest brain injury, post-cardiac arrest myocardial dysfunction, systemic ischemia/reperfusion response and persistent precipitating pathophysiology. Post cardiac arrest care must begin promptly after ROSC with a focus on supporting end-organ function, treating PCAS and addressing the underlying cause of the arrest. A systematic approach in the management of these patients is imperative to provide care to the unstable patient and to prevent further decompensation. The goal of PCAC is to increase not only survival to hospital discharge but also survival with a favorable neurological outcome.

Definitions

- **Cardiac Arrest:** Abrupt loss of heart function in a person who may or may not have been diagnosed with heart disease
- **Return of sustained circulation (ROSC):** Includes circulation that results either from a perfusing spontaneous heart rhythm or from establishment of extracorporeal circulation with extracorporeal membrane oxygenation (ECMO)
- **Altered Mental Status:** An abnormal state of alertness or awareness. For this pathway includes:
 - Patients with persistently altered mental status
 - Patients with altered mental status resulting from injury, illness, sedative medications or other therapies that prohibit a full neurologic exam
- **Targeted Temperature Management (TTM):** Specified targeted temperature control to either hypothermia (32°C – 34°C) or normothermia (36°C – 37.5°C)

Diagnosis

Inclusion Criteria

All patients who have an OHCA or IHCA and regain spontaneous circulation after CPR lasting greater than or equal to 1 minutes or undergo eCPR (CPR with cannulation to ECMO)

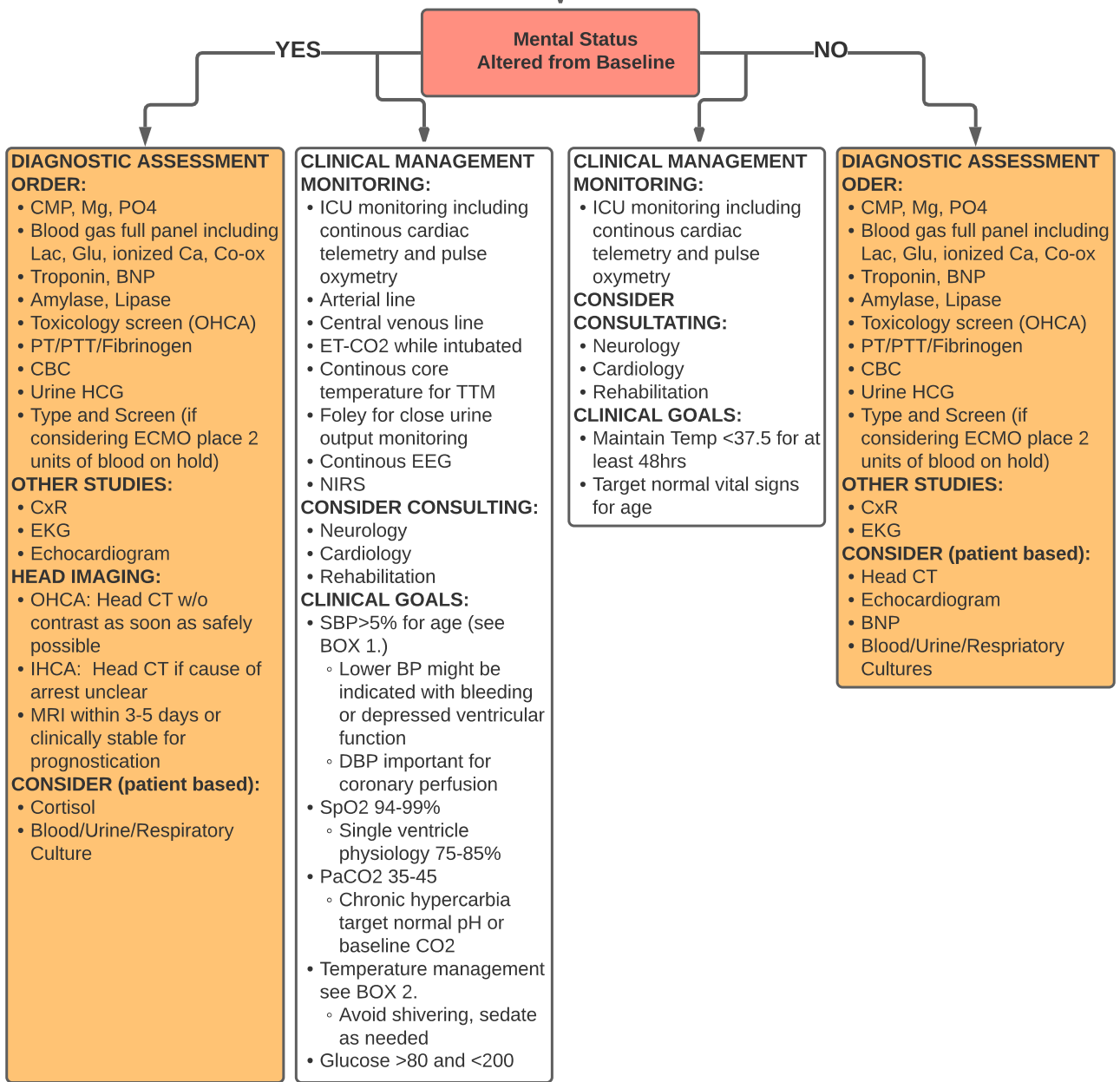
Exclusion Criteria

Patients in NICU will follow NRP guidelines.

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- Inclusion Criteria:**
- All patients who have an OHCA or IHCA and regain spontaneous circulation after CPR lasting greater than or equal to 1 minute or undergo eCPR (CPR with cannulation to ECMO)
- Exclusion Criteria:**
- Patients in NICU will follow NRP Guidelines

Cardiac Arrest with Return of Spontaneous Circulation (ROSC) after CPR greater than or equal to 1min or undergo eCPR



BOX 1. GOAL BLOOD PRESSURE

Age	MAP	SBP
Neonate	> corrected gestational age in weeks	> 60
0 to 6 months	> 45	> 70
> 6 mos - 2 yrs	> 55	> 80
> 2 yrs - 10 yrs	> 65	> 90
> 10 yrs	> 75	> 100

BOX 2.
For infants and children between 24hr-18yr of age who remain comatose after OHCA and IHCA, it is reasonable to use either:

1. TTM 32C-34C for 48hr followed by 3 days of TTM 36-37.5C or
2. TTM 36C-37.5C for 5 days

Guidelines for Patients with Altered Mental Status

Initial Evaluation

- Comprehensive physical exam including a comprehensive neurologic exam
- Diagnostic Assessment

Diagnostic Assessment - Patients with Altered Mental Status	
Laboratory studies	Complete Metabolic Panel (CMP) Magnesium Phosphorus Full panel blood gas with ionized Calcium, lactate, glucose Troponin BNP Amylase, lipase Toxicology screen (OHCA) PT/PTT/Fibrinogen CBC Urine HCG Type and Screen (If considering ECMO - place 2 units of blood on hold)
Other Studies	CXR EKG Echocardiogram
Head Imaging	OHCA: Obtain head CT without contrast as soon as safely possible IHCA: Obtain head CT if cause of arrest is unclear MRI within 3-5 days or when clinically stable to support prognostication
Labs/Studies to consider based on patient	Cortisol Cultures- Blood/urine/respiratory

Clinical Management for Patients with Altered Mental Status

Monitoring

- ICU Monitoring including continuous cardiac telemetry, pulse oximetry
- Arterial Line
- Central Venous Line
- End Tidal CO₂ while intubated
- Continuous core temperature for TTM
- Foley for close urine output monitoring
- Continuous EEG
- NIRS

Suggested Lab Schedule

- Q2H Glucose (TTM 32°C - 34°C)
- Q4H Full panel blood gas with ionized Ca, lactate, BMP, Magnesium, Phosphorus
- QDay CBC, PT/PTT/Fibrinogen, CMP, Amylase, Lipase, Central Venous Saturation

Suggested Consults

- Neurology – Interpret EEG and assist in prognosis
- Cardiology – If concern for cardiac cause of arrest including arrhythmia
- Rehabilitative Services – PM&R, PT, OT and Speech Therapy
- Additional consults as needed

Clinical Goals and Strategies for Patients with Altered Mental Status

Hemodynamic Optimization: Blood Pressure

Hemodynamic instability is common after ROSC. Early hypotension after cardiac arrest is associated with lower survival to hospital discharge. Currently, there is no high-quality evidence to support a specific strategy for post-cardiac arrest hemodynamic optimization in children.

Treatment of blood pressure to avoid hypotension is recommended. Treatment strategies are to be determined by the clinical team as indicated by the patient's medical history and clinical state. Parenteral fluids, inotropes and vasoactive medications are to be used to **maintain a systolic blood pressure greater than the fifth percentile.**

Diastolic blood pressure is an important consideration to ensure adequate coronary perfusion and myocardial recovery.

Below are recommended blood pressure goals based on the Pediatric Resuscitation Quality Collaborative.

Minimum Blood Pressure Goals: Mean Arterial Pressure (MAP) & Systolic Blood Pressure (SBP)		
Age	MAP	SBP
Neonate	> corrected gestational age in weeks	> 60
0 - 6 months	> 45	> 70
> 6 months - 2 yrs	> 55	> 80
> 2 yrs - 10 yrs	> 65	> 90
> 10 yrs	> 75	> 100

** Lower blood pressures may be indicated for patients with bleeding or severe ventricular dysfunction. Higher blood pressures may be indicated for patients with high central venous pressure or to obtain a targeted cerebral perfusion pressure.

Vasoactive Medications			
Medication	Receptor/Mechanism	Dose	Clinical Effect
Dopamine	+ β 1 + α 1, +++ β 1 ++ α 1, +++ β 1	1-5 mCg/kg/min 5-9 mCg/kg/min 10-20 mCg/kg/min	Increased SVR and cardiac index
Epinephrine	++ α 1, +++ β 1 +++ α 1, ++ β 1	0.01-0.05 mCg/kg/min 0.05-0.3 mCg/kg/min	Increased SVR and contractility
Norepinephrine	+++ α 1, + β 1, + β 2	0.05-2 mCg/kg/min	Increased MAP and SVR
Vasopressin	V1 receptor	0.5-2 MILLlunits/kg/min	Increased SVR
Milrinone	Type 3 phosphodiesterase inhibitor	0.25-1 mCg/kg/min	Increased cAMP and contractility

Arrhythmias

Abnormal rhythms, including premature atrial and ventricular contractions, supraventricular tachycardia and ventricular tachycardia can be seen post-cardiac arrest. There is no evidence to support the administration of prophylactic antiarrhythmics after ROSC. For ongoing arrhythmias, medical therapy depends on underlying cardiac pathology and function and consultation with a pediatric cardiac electrophysiologist is recommended.

Oxygenation and Ventilation

Oxygenation – After ROSC aim for normal PaO₂ (or the value appropriate for the child's condition) and use the lowest fraction of inspired oxygen. Wean oxygen for goal oxygen saturation 94% to 98%. Avoid hypoxemia. AHA PALS guidelines recommend prompt arterial blood gas analysis as soon as possible after ROSC and after establishing mechanical ventilatory support. Intermittent blood gases to be obtained based on patient status.

**Patients with congenital heart disease:

- 2 ventricle patients with a right to left shunt – goal SpO₂ 80 - 99%
- Single Ventricle, shunt dependent, banded pulmonary blood flow – goal 75% - 85%

Ventilation – After ROSC aim for normocapnia – PaCO₂ 35 - 45 or PaCO₂ specific for the patient's condition. Alterations in PaCO₂ could affect outcome by exacerbating ischemic insult through hypocarbia-induced cerebral vasoconstriction or through hypercarbia-induced cerebral vasodilation.

During PCAC, lung protective strategies, including low tidal volume and positive end-expiratory pressure, are recommended to minimize lung injury.

Targeted Temperature Management (TTM)

Post-cardiac arrest elevated core body temperature is common and persistent hyperthermia is associated with unfavorable neurological outcomes in children. There is no evidence in the literature to support or refute the use of targeted hypothermia.

The 2019 American Heart Association Focused Update on Pediatric Advanced Life Support recommends:

1. Continuous measurement of core temperature
2. For infants and children between 24 hours and 18 years of age who remain comatose after OHCA and IHCA, it is reasonable to use either TTM 32C to 34C for 48 hours followed by 3 days of TTM 36C to 37.5C or to use TTM 36C to 37.5 for 5 days.

TTM is at the discretion of the clinical team caring for the patient. The two strategies are listed below:

TTM 32°C – 34°C

- Target temperature should be achieved as quickly as possible to be effective
- Duration of TTM for induced hypothermia is 48 hours
 - Sedation and analgesia may be needed to avoid shivering
- Rewarming at a rate of 0.5°C every 2 hours
- Following rewarming a TTM 36°C – 37.5°C will be continued to complete a total of 5 days of TTM

*TTM 32°C - 34°C may prolong clearance of sedative and analgesic medications. It may also delay clinical arousal by altering cerebral metabolism.

TTM 36°C – 37.5°C

- Target temperature control for 5 days

Seizures

Seizures occur in 10% to 50% of children who remain encephalopathic after ROSC and are often substantial with status epilepticus in approximately half of those children having seizures after ROSC. About half of children with post-ROSC seizures experience nonconvulsive (subclinical) seizures.

A consensus statement in 2015 from the American Clinical Neurophysiology Society Critical Care Continuous EEG Guidelines Committee recommended continuous EEG monitoring in patients who remain encephalopathic after cardiac arrest. Continue monitoring for 24 to 48 hours in most patients, but continue monitoring until after 24 hours of normothermia in patients treated with TTM 32°C - 34°C.

Glucose Control

There is insufficient evidence to determine optimal blood glucose concentration during PCAC. Both hypoglycemia and hyperglycemia has been associated with poor outcomes in critically ill children. Recommendation is to avoid and promptly treat hypoglycemia. Target normoglycemia with avoidance of severe hyperglycemia. Routine blood glucose monitoring with goal glucose > 80 mg/dl and < 180 mg/dl.

Imaging

Imaging is often done to determine the cause of the arrest and to better understand the prognosis for the child's neurologic outcome. Both Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) can be used as diagnostic and prognostic tools.

Imaging after ROSC is often considered for the following situations:

1. Child has not returned to neurologic baseline
2. Neurologic exam is confounded by sedation or neuromuscular blockade
3. Cause of cardiac arrest is unclear
4. Child has focal neurologic findings

Brain CT is a useful diagnostic study soon after ROSC when the patient is stable to identify potentially treatable intracranial causes of cardiac arrest. Brain MRI 3-5 days or when clinically stable may be helpful to support prognostication of outcome when combined with neurological examination and EEG.

SUMMARY OF CLINICAL GOALS FOR PATIENTS WITH ALTERED MENTAL STATUS

Parameter	Goal	Specific Consideration
Blood Pressure	SBP greater than the 5 th % for age	1. Lower BP goals may be indicated with bleeding or severely depressed ventricular function 2. Diastolic BP is important to maintain coronary perfusion pressure
Oxygenation	SpO2 94 - 98%	Patients with congenital heart disease
Ventilation	PaCO2 35 - 45	Patients with chronic hypercarbia - target a normal pH or their baseline CO2
Temperature	TTM 32°C - 34°C TTM 36°C - 37.5°C	Avoid fever, avoid shivering - sedate as needed
Glucose	Glucose > 80 and < 180	

Guidelines for Patients at Baseline Mental Status

Initial Evaluation

- Comprehensive physical exam including a comprehensive neurologic exam
- Diagnostic assessment

Diagnostic Assessment - Patients at Baseline Mental Status	
Laboratory studies	Complete Metabolic Panel (CMP) Magnesium Phosphorus Full panel blood gas with ionized Calcium, lactate, glucose Troponin BNP Amylase, lipase Toxicology screen (OHCA) PT/PTT/Fibrinogen CBC Urine HCG Type and Screen (If considering ECMO - place 2 units of blood on hold)
Other Studies	CXR EKG
Labs/Studies to consider based on patient	Head CT Echocardiogram Cortisol BNP Cultures - Blood/urine/respiratory

Clinical Management for Patients at Baseline Mental Status

Monitoring

- ICU Monitoring including continuous cardiac telemetry, pulse oximetry

Clinical Goals and Strategies

- Target normal vital signs for age
- Maintain temperature < 37.5 C for at least 48 hours – avoid fever
- Consider Neurology and/or cardiology consult as needed

Documentation Reminders

- Providers should use the JHH-ACH-PICU Post Cardiac Arrest Care (PCAC) Focused Order Set

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Outcome Measures:

- Order set use

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Disclaimer

Clinical Pathways are intended to assist physicians, physician assistants, nurse practitioners and other health care providers in clinical decision-making by describing a range of generally acceptable approaches for the diagnosis, management, or prevention of specific diseases or conditions. The ultimate judgment regarding care of a particular patient must be made by the physician in light of the individual circumstances presented by the patient.

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